happily adjusted to those external relations which were never more complex or more exacting than to-day,—this is our problem. We hear at present much of wars and rumors of wars, and a new social heaven—or at least a new earth that is to become a new heaven. But the universe moves on in its appointed ways. The sun and the moon and the stars and the seasons and day and night are with us, as of old. Plants and animals only slowly change their nature, and mankind is born and lives and dies much as it has always done. Art, to be sure, has become vastly longer, but life is still nearly as short as ever and relatively to the things to be seen, to be learned and to be done, infinitely shorter. The fundamental problem of all education, namely, preparation for life, is therefore no less, but rather infinitely more, important.

But with the aid of laboratories like this, generously furnished by lovers of their kind, in which wise teachers, themselves models of devotion to truth and scholarly living and endeavor, by means of examples, epitomes and recapitulations of the great experiments and discoveries of the past, shall enable their pupils to appropriate forever to themselves and to the service of man the accumulating wisdom of the ages, we may go forward with a cheerful courage. Nor does it seem too much to believe that an interpretation of nature which has robbed it of most of the terrors which it possessed for primitive man and has made it increasingly serviceable to the race, will long endure.

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THE FITNESS OF ORGANISMS FROM AN EMBRYOLOGIST'S VIEWPOINT[1]

I am glad to accept an invitation to address this club, for I believe that it is an excellent custom, indeed, almost necessary in these days of specialization, for a biologist to look at his problems now and then from others' points of view and to be brought into contact with men working on quite different aspects of life than his own. The same fundamental problems face all workers in the biological field, be they ecologists, structure-workers, process-workers, breeders, or, I might add, workers in the broad field of the medical sciences, for I believe that the clinician fully appreciates that the problems of health and disease are, on one aspect at least, problems of life and that medicine on its science side belongs in the broad field of biology. It is the unitary character of life and life phenomena that binds us all together and creates bonds of common interest and the goal toward which we all must strive, whether we know it or not—if the minor problems which we attack are correctly solved—is the explanation of life.

It is a goal which perhaps we may never reach or whose outline at some future time will be made out in but crude and hazy form, and yet it does us good ever and anon to pause in our detailed work of analysis and technique and turn our eyes in the direction we believe it lies and to ponder on the road before; it helps us I believe toward a clearer appreciation of the setting of the petty problems that immediately confront us. Perspective is too apt to be lost in the close scrutiny of high specialization. In such a contemplation from afar of the end-problem of the biologist, some, overwhelmed by what lies between, believe it unattainable; and others proclaim that the solution is close at hand; one sees in the intricacies of life evidences of a vital force while for his fellow-worker the explanation is to be wrought out in terms of physics and chemistry alone. For each the attitude of mind that will color his speculations will be compounded out of his personal make-up, the daily routine of his work and the time and concentration that he has devoted to it. The field naturalist easily inclines toward vitalism; the biochemist, perhaps, is biased toward a physico-chemical interpretation; the structure-worker —and in this group I would place myself—in

[1] Talk before the Agassiz Club of Cornell University, February 24, 1913.

more or less intimate contact with both fields, may be drawn toward the one or the other camp.

In the interpretation of life phenomena, we can not, of course, escape from the domain of physics and chemistry; the living body is material, and the fundamental physical laws of the conservation of matter and energy hold there as in the inanimate world. In the transformations that take place in organisms, there is no evidence whatsoever known to me of or the least indication that new matter has appeared or new energy been created. We are constrained therefore, if we must postulate a vital force, to conclude that it is a new form of energy developed out of the other energy forms and transformable into them again. Since we know nothing about such a special life form of energy, but only the energy of inanimate matter, there has always seemed to me no value in its assumption, since the analysis must always proceed from the known to the unknown and be expressed in terms of the physics and chemistry of the organism. If in course of time it becomes apparent that another energy form exists in living organisms, it will then be time enough to discuss it; for the present I do not believe it helps to introduce it.

In all analysis of life phenomena, very fundamental it seems to me is the analysis of *life conditions,* those absolutely essential for its manifestation, and you will, I know, pardon my introducing here so elementary a matter as their enumeration. They are: (1) Food-stuffs, *i. e.,* the necessary chemical conditions; (2) oxygen; (3) water; (4) heat, *i. e.,* the adequate temperature; (5) pressure. Out of these, together with a few more that rest upon them as a basis—(6) protection, of diversified forms; (7) elimination of useless material; (8) formation of new individuals as centers of organic transformation—are compounded the fundamental life activities, of the higher organisms at least. It is hardly necessary to insist upon the broad application of the above thesis. Following through the sum total of the activities of an organism—and I would include its structure as but the partial expression of these same activities—untangling in your analysis the complex that they form you come back to the fundamental categories of life manifestation enumerated above and the conditions that underlie them. There is, of course, nothing fundamentally different in the manifestation of life under the given necessary conditions and a chemical or physical reaction. To take a simple example, the rusting of iron. Given the necessary conditions, namely, the presence of water, oxygen, some acid, I am told, such as carbonic acid, and of course iron, under an adequate temperature, and the reaction will proceed at a given rate. Under somewhat different and more complex conditions, the presence of some other acid or salt, and with less pure iron, the reaction will proceed more rapidly. But I am venturing on rather dangerous ground and must withdraw.

There are two aspects of life manifestation which I desire to mention and which will introduce the subject that I chose to discuss with you. The first of these is the continuity of life and all that it includes—growth and reproduction. This in itself would possibly be regarded as more intimately characteristic of life, but I believe that if we were to stop to analyze it out, we would find nothing distinctive in mere continuity. One might, I think, find illustrations of purely physico-chemical reactions taking place in the earth's crust to-day that have been proceeding since its foundations. It is that in organisms *insuring* the continuity which is peculiarly biological. The molding of the life activities of organisms to a more or less specific environment supplying the necessary life conditions so that environment and organism constitute an interrelated system of more or less complexity, is the second aspect I made reference to, and adaptation[2] appeals to me as a second very fundamental fact in biology. Of the truth of this and the great diversity of patterns in which life activities and environment are interwoven in different organisms, you doubtless know better than I who have largely only

[2] The term is employed in the broad sense, and as a passive instead of active noun.

second-hand knowledge of ecological relations. The constancy as well as the complexity of each pattern is the striking thing.

I trust you see with me that there is nothing in the mere element of *fitness* that is peculiar to life. Any chemical reaction requires a fitness of conditons, if we choose to use the word. It is the *pattern* that embodies elements more peculiarly biological. The pattern in the world of living things at the present day is complex indeed, but particularly so in the higher animals, in whose evolution there has been established a complexity of pattern in which the woof colors of organism more and more dominate the warp of outside environment, or, to abandon the metaphor, in the thought of Professor Matthews at the recent symposium on Adaptation, the highest step in the perfection of adaptation has been reached by making the organism superior to, adapted to, all environments; or, differently put, in the taking the immediate life condition environment within the organism itself.

And now we come to the critical point in our attitude toward adaptation. In the use of such terms as fitness, adaptation, control of environment, we invoke teleology. The objection has been raised, and I believe rightly, that to an analysis in terms of cause and effect any consideration of use, purpose, or aim must be extraneous. We should in all instances differentiate between the explanation of the phenomena and whatever teleological significance may attach thereto. The analysis may perhaps not necessarily be directly in terms of matter and energy, but it can take no cognizance of a teleology as a link in the chain. I should like to discuss this aspect of the adaptation problem at some length, but time is inadequate. Here, however, we stand at the branching of the road, we have a choice before us. (1) Either there must be found some substitute for the term adaptation that will avoid the teleological element, or (2) accept a pervading life force in all organisms, animal or plant, whose highest development appears in human consciousness and intelligence, a mind force coextensive with the matter and energy of organized matter. Some day we may be compelled to postulate a directive principle such as the entelechy of Driesch, but I do not believe its assumption at the present stage of knowledge and analysis is necessary or helpful. Personally I believe that the right road leads toward an ultimate analysis and recasting of what we mean by adaptation. The recasting, however, must needs strike deep: ideas of cooperation of organs with specific functions, expressing a division of labor, belong in the same category. The unitary character of the entire life processes and the structure as but the material expression of these is it seems to me the keynote that must be struck and emphasized in all our analyses of life phenomena on the side of explanation in the terms of cause and effect.

And yet I think that the belief prevailing in some quarters that all in life may be explained in terms of physics and chemistry errs equally on the other side. Life in an organism to-day is like a tapestry in which the threads of warp and woof are woven into a pattern of exceeding intricacy and delicacy whose weaving has been going on since the beginnings of life. You may analyze the threads of process as they run in and out to-day in terms of chemistry and physics, it may be, but the pattern stands as a history of the past and the weaving is still largely a secret of the ages. The pattern is the problem of evolution, and inheritance if you will. For me, the pattern in which the life activities of any organism are expressed is threefold, expressed by the words adaptation, form, consciousness. No one of these can I conceive as being explainable in physico-chemical terms. Granting that some day you may know the full chemistry (or physics) of the formation of secretin and how it causes the secretion of the pancreatic juice, there will still remain unexplained the adaptation. Full knowledge of the gross and fine anatomy of the face, the morphogenesis and histogenesis of its development and analysis of the physico-chemical processes underlying these, would, it seems to me, leave still unexplained the cast of feature. Even if we assume that future workers will be able to un-

ravel the complex histological tangle of the cerebrum and analyze the physico-chemical processes that take place therein when it is active, consciousness will remain incomprehensible on such a basis. I have been told of a man who was working on the physical-chemistry of instinct. I feel sure our psychological friends would reject with laughter such a thesis; they might perhaps accept it if it were worded as the physico-chemical processes underlying instinct. You can not analyze the pattern by analyzing the component threads, although that might help you in the end toward fully understanding the pattern. I do not believe you can analyze the pattern of the life activities in an organism, including of course its "behavior," by analyzing the threads of process that compose it. Try it, and I prophesy that failure will result, or you will resort to the assumption of an autonomous vital principle, as Driesch has done. You can not analyze phenomena of one category in terms of those of another. It is possible of course that in time we shall know so much of the activity pattern of organisms and how it was evolved that we shall be able to solve the problem of life, but I do not believe the explanation is so close at hand as some would have us believe, and perhaps we shall never know from inability to unravel the past.

You may gather from what I have just said that so far from regarding those of you working along ecological lines, as I know some of you are, as straying from the road that leads toward the explanation of life, I would consider you as pursuing lines of work in a field peculiarly biological for which I know of no broader and better term than that proposed by Minot—bionomics. My only comment is that such work should be analytical and not merely descriptive, and you can not neglect the texture of the fabric in tracing the pattern.

I have now, I fear, gone far afield in laying before you my attitude toward adaptation and have little time in which to present one or two aspects of the subject that are of interest to the embryological worker and to you as members of a peculiarly bionomic club, if you will let me use the term. If in the following I speak of adaptation, fitness, function, purpose, I shall do so for simplicity's sake to avoid complicated paraphrases, using them as pattern terms solely. As one who is particularly interested in the analysis of structure, I can not but feel the all-pervading element of fitness—adaptation—in structure, and the importance of having a clear conception of what it stands for when interpreting structure. Whatever portion of the organism you select for critical examination offers illustration many-fold, so that I have been puzzled that the existence (not interpretation) of adaptation can be questioned. There are, however, structures in the vertebrate body, as you doubtless know, in which adaptation does not stand revealed; I refer to vestigial structures which, however, stand for adaptations, not present but past, and may be divided into two somewhat distinct groups, of which I will venture to present one or two illustrations. Again I will recall familiar facts to you, from a rather different point of view, perhaps.

The past history of organisms is reflected, however imperfectly, in their development. Past adaptation patterns, no longer applicable, continue over. They may, or may not, play a part in meeting the life condition complex with which that organism is interwoven. The quality of fitness in them may exist or appear to be quite lacking. Numerous illustrations may be chosen from the embryology of vertebrates which are thoroughly familiar to you. The development of the branchial chamber, expressing a fundamental adaptation pattern in the lower vertebrates, subserves no such useful purpose in the higher forms. In connection with it come certain intensely interesting structures in which adaptation may or may not be revealed. I can not appreciate the functional importance of the thymus coming from the third branchial pouch, nor of the similar structure occasionally developing from the branchial chamber farther back. To me the tonsils have no deep hidden part to play in the bodily economy but, useless and in some cases detrimental, stand for a tiny portion of an adaptation that is past. No specific functions have been revealed; but in saying this,

do not understand me to say that these structures are not without a possible effect in the organism. The mesonephros of mammals likewise represents an important adaptation of the past, but Felix has once and again pointed out that evidence of an excretory function is lacking. But these illustrations will suffice. As a record of the past history of the race, they stand as a testimony to the very change in adaptation that the organism has undergone with the progress of time and evolution. As such they afford valuable clues and are thus of taxonomic value.

In the second group I include those adaptations that exist or appear in the course of development to meet the life conditions peculiar to that period. These structures introduce complexities in development. They are present at one period of the life cycle and pass away with changed conditions. Where traces of them remain, they are like the vestigial structures of the first group, a record of past adaptations, but in the individual history and not primarily that of the race. As an example, the Kiemenreste (gill-remnants) of frogs and toads stand as a record of the early adaptations of the frog in its larval period. No function can be assigned them; they appear to have no past history in the race. Again let me repeat I do not say that they may not be without effect in the organism. The most noteworthy instances in this group of structures of interest to the vertebrate embryologist are the fetal membranes, structures developed out of the animal's body (essentially) mainly for the protection, nutrition and respiration of the individual during the early period of its ontogeny and subsequently discarded when no longer needed. Since they are outside the body, they are not continued as vestigial structures; only insignificant folds and so-called ligaments remain as more or less useless remnants.

Such transient adaptations in the individual life history have, of course, been evolved and perfected in the evolution and share with those of the first group a taxonomic value, but with this difference: such adaptations to meet very specific needs at a specific period in the individual's life should, I believe, be used with caution. Let me give the two examples that have impressed me most.

In the development of the fetal membranes of mammals a very marked variation in the arrangement in the different forms occurs. In general the plan of development and relations appears to be broadly characteristic of the different orders. In perhaps the majority the amniotic cavity is formed by folding essentially as in the reptiles and birds. In certain of the rodents, chiroptera, insectivora, and probably primates, however, the amniotic cavity appears precociously in the midst of the ectoderm or trophoblast and only subsequently do the typical structure and relations of the amnion become established. An eminent embryologist of Europe, Hubrecht, to whom are due many of the facts of the early development in these forms, concluded that this method of formation of the amniotic cavity, by dehiscence, is the primitive type and therefore decides in favor of an origin of the mammals from amphibian-like forms. This method of amnion formation appears, however, closely correlated with the method of implantation of the ovum and placenta formation, and inasmuch as the type of placentation represented is obviously the highest and most direct the primitive character of amnion formation by dehiscence may be seriously questioned. The uselessness of such a character for taxonomic purposes is further illustrated by the fact that in but one of the four groups where it occurs is it apparently constant, but amnion formation by folding is found as well in certain of the forms.

My second illustration of the questionable character of such ontogenetic adaptations as clues to genetic relations is the tadpole stage of frogs and toads. The structural relations of the larval organism depart in detail so widely from the typical relations and are so obviously correlated with the immediate life conditions that one is justified, I believe, with Spemann and Versluys in regarding the adult as probably standing nearer the "ancestral line." Founding broad genetic conclusions from the conditions in the tadpole may be done only with caution and reserve. The per-

version of fundamental relations in the larva is well illustrated in the development of the middle ear and sound-transmitting apparatus where my personal interest has centered.

Thus the embryologist in attempting to explain development encounters illustrations of the formation of apparently non-adaptative structures and structures whose adaptative value has apparently been lost. The idea of adaptation must be ever present with him and yet he must avoid the assumption of a "function" for all things, or seek "fitness" as the key to the interpretation of structure. The field or work for him is first of all the analysis of the underlying developmental processes in which adaptation is portrayed. There are, however, always the two aspects, pattern and texture, in life activities.

Illustrations of apparently non-adaptative structures which apparently never are or were adaptative will doubtless occur to you, many of them correlated with sex; others apparently useless and seemingly a pure exuberance of growth and behavior. These I can not discuss; they lie outside my field. They emphasize again that the secret for them as for adaptation lies wrapped up in the complexity of life processes with the obscure and prolonged evolutionary history involved, and our only hope lies in analysis.

B. F. KINGSBURY

THE FINAL EXAMINATION OF SENIORS IN AMERICAN COLLEGES

WHETHER seniors at the end of their college course should be required to take examinations at the same time as other students, or several days or weeks earlier, or whether they should be excused from examinations altogether upon the basis of their term standing, is a problem which is not infrequently up for discussion. While one may hardly hope to settle the matter absolutely, to know the practise in different institutions throughout the country may not be without value.

Early in May, 1912, I sent out a postal questionnaire to all the institutions listed under the head of "Universities, colleges and technological schools for men and for both sexes" in the Report of the Commissioner of Education for 1909, which was the latest volume accessible to me at that time. There were but two questions asked, viz., "Do the seniors in the collegiate department of your institution take their final examinations in the spring term, or second semester, at the same time as, or two or three weeks earlier than, the rest of the students?" "Are some of the seniors excused from the final examination upon the basis of their high average, 85 per cent., 90 per cent., 95 per cent., during the spring term, or second semester?" Of the 493 institutions to which postals were sent, 347 replied, and those replies throw at least some light upon the problem.

The simplest method of dealing with this material is to take the undifferentiated list of institutions in its entirety. Of the total number, 493, 70 per cent., were heard from. Of these, 167 require the seniors to take their final examinations at the same time that the rest of the students do, while 154 set the senior examinations at an earlier date. There were, also, 26 replies which were not definite. This majority of 13, while not great, becomes more significant when one considers the variety which prevails among the other institutions. The date for these earlier examinations varies from two or three days before the regular examinations to seven or eight weeks. The tendency, however, is to have them scheduled one or two weeks earlier, as is shown by 68 and 46 postals, respectively.

The following tables are in the main self-explanatory.

TABLE I

Institutions at which Final Examinations for Seniors are Scheduled Earlier than for Underclassmen

Two or three days earlier	3	Two or three weeks earlier	19
Five days earlier	1	Three weeks earlier	8
Ten days earlier	3	Three or four weeks earlier	1
One week earlier	68	Four weeks earlier	1
One or two weeks earlier	2	Seven or eight weeks earlier	1
Two weeks earlier	46	Scattering[1]	1
Total	123	Total	31

[1] This term designates a card which indicated that some of the examinations are earlier, but did not specify definitely.